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ABSTRACT

The author estimates that a minimum of 3600 additional mathematics teachers and 1800 additional science teachers will be needed at the secondary school level over the next several years. Each of the following trends is discussed: (1) increases in high school graduation requirements will increase the need for mathematics and science teachers; (2) declines in high school enrollment will decrease the need for mathematics and science teachers; (3) enrollment in teacher training programs for mathematics and science teaching is likely to decline; and (4) mathematics and science teaching is likely to become less attractive in comparison to other careers. Of these trends, the author believes that the one with the greatest potential impact is the trend toward increasing high school graduation requirements. However, new teacher demand created by this trend will be somewhat offset by decreases in secondary school enrollment. (MNS)

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PROJECTIONS OF FUTURE SHORTAGES OF MATHEMATICS AND SCIENCE TEACHERS[1/]

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Current evidence suggests that teacher shortages now being experienced in mathematics and science are likely to grow in the near future. Based on assumptions and calculations described in this paper, a minimum of 3,600 additional mathematics teachers and 1,800 additional science teachers will be needed at the secondary level over the next several years. This growth in the number of teachers needed will be shaped by trends in (1) increases in high school graduation requirements, (2) decreases in numbers of students enrolled in secondary schools, (3) decreasing enrollment in teacher training programs, and (4) decreasing attractiveness of teaching careers in comparison to other occupations available to persons trained in mathematics or science. Among these four, the two trends likely to have the greatest impact on teacher shortages are the widespread increases in high school graduation requirements in mathematics and science and decreases in secondary school enrollment. New teacher demand created by the former trend will be somewhat offset by the latter. Each of the four trends is discussed in the sections that follow.

1. Increases in high school graduation requirements will increase the need for mathematics and science teachers.

A number of states have recently raised statewide requirements for high school graduation. Other states are likely to follow in the next year or two. According to a 1983 telephone survey conducted by the National Center for

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Education Statistics (NCES), as supplemented by news reports compiled through 1983 by the Education Analysis Center for Educational Quality and Equality, 19 states have increased graduation requirements in mathematics since 1980, and six other states are seriously considering increases. In science, nine states have increased graduation requirements during this period, and 10 states are seriously considering increases. Table 1 identifies the states that have made or are contemplating these changes. The appendix to this paper presents state-by-state data on high school enrollment and mathematics and science coursework requirements.

The trend among states is generally toward the imposition of more stringent requirements in all subjects. These moves represent efforts to raise educational achievement in general and particularly in mathematics and science. This trend has probably been strengthened in the past year due to recommendations for stiffer graduation requirements made in reports such as those of the National Commission on Excellence in Education and the Twentieth Century Fund. Because requirements for subjects such as English have always been high (e.g., 20 states required four years of English prior to 1980), increases in graduation requirements are likely to have a disproportionately large effect on mathematics and science, resulting in greater needs for new teachers in these areas. Any increase in high school graduation requirements in mathematics or science is likely to increase the numbers of teachers needed in those subjects.

To determine the number of new teachers needed as a result of recently enacted and proposed changes, it is necessary to know the current numbers of students taking varying amounts of mathematics and science coursework. This information is needed because increases in course requirements will only affect the courses taken by students who currently enroll in the minimum number of courses required for graduation. For example, an increase from one to two years of mathematics required for graduation will have no effect on students already taking two, three, or four years of high school mathematics. In a state where graduation requirements are increased from one to two years, additional teachers will be needed only to provide instruction to those students currently taking no more than one year of mathematics during their four years of high school. Using data collected by the NCES survey, High

Table 1

States[a/] Increasing or Considering Increases in Graduation Requirements in Mathematics and Science, as of January 1984

Subject	Requirements Recently Increased			Currently Considering Increases		
	From 1 year to 2 years	From 2 years to 3 years	From 1 year to 3 years	From 1 year to 2 years	From 2 years to 3 years	From 1 year to 3 years
Math	Alabama Arizona Delaware D.C. Idaho Indiana Nevada New York North Carolina North Dakota Ohio Oklahoma South Dakota Tennessee West Virginia	Louisiana Texas	California Florida	New Hampshire Virginia	Kentucky New Mexico South Carolina	Rhode Island
Science	Arizona California Delaware Indiana New Mexico Oklahoma South Dakota Tennessee	--	Florida	Illinois Kansas New Hampshire New York Rhode Island South Carolina Virginia	--	Arkansas Missouri Pennsylvania

[a/] Includes the District of Columbia.

Source: NCES, 1983; Parrish, 1981; ED Office of Issues Analysis, 1983; news reports from Education Week, 1983.

School and Beyond, Table 2 contains estimates of the cumulative percentages of high school seniors in 1980 who took one, two, three, or more years of mathematics and science courses during high school.

Table 2

Cumulative Percentages of 1980 High School Seniors
Taking Varying Amounts of Mathematics and Science Coursework

Amount of Coursework	Mathematics	Science
Total, including those with no coursework	100%	100%
One year or more	93	90
Two years or more	67	53
Three years or more	34	23

Source: "A Capsule Description of High School Students," NCES, April 1981.

Because it is impossible to know precisely how many states will increase their high school graduation requirements, the analysis of effects of changing graduation requirements has been designed to yield a range of likely needs for new teachers. For the analysis presented here, the low end of the range assumes that the increases in requirements that have already been adopted will actually be implemented in the states that are shown in Table 1 as having recently increased requirements. Our mid-range estimate assumes that, in addition to the requirements already adopted, all states currently considering increases will actually implement those increases. At the high end of the range, we have assumed that all states will implement the recommendations offered by the Excellence Commission for a required three years of mathematics and three years of science prior to high school graduation.

Using these assumptions to structure the analysis (and ignoring for now other trends that might affect the need for high school teachers), we estimate that a minimum of 8,600 new mathematics teachers will be needed in the next several years; our mid-range estimate is that 12,600 new mathematics teachers

will be needed; and at the high end, we estimate a need for 29,000 new mathematics teachers. We also estimate that at least 6,500 new science teachers will be needed; at the mid-range we estimate a need for 13,000 new science teachers; and our high estimate is for 40,600 new science teachers. These levels of potential need, if realized, would obviously have a massive effect on the public schools, even at the lower estimated levels. The following sections describe how these projections of national need have been reached.

Minimum projected level of increased need for mathematics and science teachers. To compute the number of new teachers needed if all recent increases in Table 1 are fully implemented, high school enrollment figures for each of the states shown in the table were determined, as seen in the appendix. Then, the number of students taking additional mathematics or science courses in each state was estimated, using new estimates derived from Table 2. Because states require varying amounts of coursework for graduation, we recomputed current national levels of mathematics and science coursework to reflect varying state requirements. These new estimates are presented in Tables 3 and 4 for mathematics and science, respectively. The estimates presented in these two tables were calculated using the assumption that all high school students plan to graduate and therefore fulfill the graduation requirements of their respective states. (For example, in all states that require two years of

Table 3

Estimates of Cumulative Percentages of 1980 High School Seniors Taking Varying Amounts of Mathematics Coursework in States with Varying Mathematics Requirements for Graduation

Amount of Coursework	Graduation Requirement			
	One Year	Two Years	Three Years	Local Option
Total, including those with no coursework	100%	100%	100%	100%
One year or more	100	100	100	80
Two years or more	57	100	100	57
Three years or more	33	33	100	33

Table 4

Estimates of Cumulative Percentages of 1980 High School Seniors Taking Varying Amounts of Science Coursework in States with Varying Science Requirements for Graduation

Amount of Coursework	Graduation Requirement		
	One Year	Two Years	Local Option
Total, including those with no coursework	100%	100%	100%
One year or more	100	100	71
Two years or more	43	100	43
Three years or more	23	23	23

mathematics for graduation, we assume that all students will take at least two years of mathematics.) After estimating new mathematics and science enrollments, the number of new teachers needed was calculated by assuming that a mathematics teacher would provide instruction to 125 students a year (i.e., 25 students in each of 5 classes) and that a science teacher would provide instruction to 113 students (i.e., 25 in each of 4.5 classes).[2/]

Using Alabama as an example of this analytic procedure, calculations were performed to determine the effect of increases in graduation requirements from one year to two years of mathematics. With a total high school enrollment in Alabama's public schools of 235,000, each cohort of seniors (numbering approximately 58,750 students)[3/] will now be required to take a minimum of two years of mathematics during high school, an increase from the state's earlier requirement of one year. To determine the number of students affected by the change,

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2/ According to the National Science Teachers' Association, the average full teaching load for science teachers is 4.5 classes.

3/ These calculations assume that each cohort of seniors equals one fourth of all students in grades 9 through 12. In fact, the proportion is probably lower, due to dropouts. Nevertheless, in estimating the effects of new requirements, we assumed that the coursetaking of all students would be affected.

we subtracted (1) the estimated 57 percent of Alabama seniors who have taken two or more years of mathematics from (2) all Alabama seniors. This calculation indicates that almost 25,300 students in Alabama will be taking one more year of high school mathematics than they otherwise would have taken. If each mathematics teacher can provide instruction to 125 students per year, approximately 200 new mathematics teachers will be required in Alabama as a result of the increased mathematics requirement.

This estimate is somewhat misleading, however, because it implies a level of efficiency in the creation of new mathematics classes and the assignment of new teachers that is simply not feasible. Alabama, for example, has more than 200 high schools. School districts will, therefore, be required to design new mathematics staffing plans that include (1) the reassignment of some current mathematics teachers, (2) increases in teaching loads of some current mathematics teachers, and (3) the hiring of new mathematics teachers. Whether the end result is a net increase state-wide of 200 mathematics teachers or more or fewer will depend on many factors, including the local availability of new mathematics teachers.

Using this analytic technique, the number of new mathematics teachers needed nationwide was calculated to be approximately 8,600, assuming that the 19 states in Table 1 having recently increased their mathematics requirements actually implement those increases. Using the same technique, the number of new science teachers needed was calculated to be 6,500, if the nine states in Table 1 having recently increased science requirements actually implement those increases.

We did not attempt to determine which of the needed new science teachers would be required for various subject areas, such as chemistry, biology, and physics. To do so would require estimation of students' probable new course-taking habits under revised graduation requirements, which we were not able to do. For example, it seems likely that a student who enrolls in an additional science course to fulfill new graduation requirements would tend not to take a course that is known to require a fairly high level of intellectual effort (e.g., chemistry or physics). Unless required to do otherwise, that student would probably take a second-year science course known to be somewhat easier. However, because no basis exists from which to estimate students' actual decisions in those cases, no attempt has been made to project likely need for additional teachers of particular science subjects.

Mid-range of estimated need for mathematics and science teachers. To determine the probable mid-range of need for new mathematics and science teachers, we assumed that all of the increases shown in Table 1, both recent increases and those under consideration, were actually implemented. The same estimating technique used for the low-end estimates was applied in calculating these levels of possible need. Using those methods, we determined that 12,600 new mathematics teachers and 13,000 new science teachers would be needed if all recent and proposed increases were implemented.

Maximum projected level of increased need for mathematics and science teachers. To determine the highest realistic need for additional mathematics and science teachers, we assumed that the Excellence Commission's recommendations would be implemented in all states. As previously noted, these recommendations would require that all high school students take three years each of mathematics and science.

To calculate the number of new mathematics and science teachers needed under that assumption, we used the national public school enrollment and assumed that students' current coursework in mathematics and science reflected the proportions shown in Table 2. Thus, for each current cohort of students (numbering approximately 3,423,500 students), the numbers of students taking varying amounts of coursework would be those contained in Table 5.

Table 5

Numbers of Students in One High School Cohort
Taking Varying Amounts of Mathematics and Science Coursework

Amount of Coursework	Mathematics	Science
Total	3,423,500	3,423,500
No coursework	239,600	342,300
One year only	890,200	1,266,700
Two years only	1,129,700	1,027,100
Three years or more	1,164,000	787,400

If the proposed Excellence Commission requirements for mathematics were implemented, one set of students (i.e., the 1,164,000 students now taking three or more years of mathematics) would make no changes in coursework. A second set of students (i.e., the 1,129,700 students taking two years of mathematics) would take one additional year. A third set of students (i.e., the 890,200 students taking one year of mathematics) would take two additional years. A fourth and final set of students not now taking mathematics at all (i.e., 239,600 students) would take three years of mathematics. The total number of students affected by this change would thus be those from the second, third, and fourth sets described above. Students in the second set would be counted once because they would be taking one additional year of mathematics, students in the third set would be counted twice because they would be taking two additional years of mathematics, and students in the fourth set would be counted three times because they would be taking three additional years of mathematics. Thus, the weighted number of students affected by the change would be the sum of these students, or 3,628,900. Assuming each new mathematics teacher could provide instruction to 125 students, a total of 29,000 new mathematics teachers would be required to provide the mathematics instruction recommended by the Excellence Commission.

Using the same analytic technique in computing the need for science teachers (but assuming that each science teacher can provide instruction to only 113 students), a total of 40,600 new science teachers would be required.

2. Declines in high school enrollment will decrease the need for mathematics and science teachers.

The trend towards declining high school enrollments will partially offset the increase in the number of mathematics and science teachers who are needed due to increased graduation requirements. According to NCES projections, national enrollment in grades nine through twelve is expected to continue the decline apparent in recent years. From the 1982 enrollment level of 13.8 million students, enrollment is expected to decrease to 13.2 million students in 1987 (NCES, 1982). If we assume that the number of teachers who are needed is proportional to the number of students enrolled in high school, then there

should be a 4.6 percent decline from 1982 to 1987 in the number of persons needed to teach mathematics and science. Thus, by 1987 approximately 5,000 fewer mathematics teachers and 4,700 fewer science teachers will be needed than were teaching in 1982.

The decline in enrollment is expected to continue into the early 1990's. The trend will then be reversed and high school enrollment will increase throughout the remainder of that decade.

3. Enrollment in teacher training programs for mathematics and science teaching is likely to decline.

As seen in information presented by Pelavin, Reisner, and Hendrickson (1984), the selection of mathematics education and science education majors by college students has declined dramatically in recent years. There is no reason to believe that this pattern of decline is likely to be reversed--under current conditions, at least. With fewer mathematics and science teacher candidates being produced through traditional programs of education majors, it is logical to expect that this source of new teachers will account for only a very small number of new teachers in the near future.

The other source for the production of mathematics and science teachers by teacher training programs consists of students majoring in mathematics or a science who take enough education courses to attain accreditation. However, the total number of mathematics and science majors becoming teachers has also been declining and is currently estimated to be quite small. Moreover, these numbers seem unlikely to grow in the near future, as discussed in the next section.

4. Mathematics and science teaching is likely to become less attractive in comparison to other careers.

For college students interested in careers in mathematics and science, a major factor discouraging interest in teaching has been the attractiveness of other types of careers, including those in "high technology" fields. In comparison to teaching, jobs in the private sector tend to offer at least three

serious inducements to college students who have majors in mathematics or a science. These include higher salaries, better chances for career advancement, and greater opportunities to work with modern equipment (especially, computer and laboratory equipment). In many cases, the career opportunities outside teaching offer advantages in these three areas that represent significant, not just marginal, improvements over teaching.

For bachelor's degree graduates in mathematics or science, the salary advantages outside teaching are dramatic and growing. For example, in 1976 the mean annual salary of all holders of bachelor's degrees in mathematics was 47 percent higher than salaries of teachers who had bachelor's degrees in mathematics. By 1980, however, that difference had grown to 71 percent (Botts, 1982). Similarly, in 1971 the mean annual salary for all holders of bachelor's degrees in physics was 24 percent higher than salaries of teachers who had bachelor's degrees in physics. By 1981, however, the salary difference had more than doubled (Ellis, personal communication, 1982).

The higher salaries available for mathematics and science graduates in the private sector reflect the generally high demand for such personnel. Indeed, career opportunities in these areas are growing rapidly, as seen in employment projections developed by the Bureau of Labor Statistics (1982). For example, the Bureau predicts that employment for mathematical scientists, such as actuaries and statisticians, will grow as fast or faster than average. In addition, most physical science occupations (e.g., chemists, geologists, and geophysicists) and some biological science occupations (e.g, biochemists, agriculture and biological scientists) will offer very favorable employment prospects. Thus, employment opportunities outside the classroom are likely to encourage many mathematics and science teachers to leave teaching.

5. Of the future trends described here, the one with the greatest potential impact is the current trend towards increasing high school graduation requirements.

If states increase graduation requirements in mathematics and science, as currently expected, local school systems will need significant numbers of new teachers of mathematics and science to provide the required instruction.

Although these pressures will be partially offset by declines in high school enrollment, these decreases will provide relatively little relief especially if additional states implement the increases in graduation requirements that they are currently considering. The states that have already increased graduation requirements will create in the next four to five years the need for 8,600 additional mathematics teachers and 6,500 additional science teachers. Although the projected decline in enrollment will reduce the need for additional mathematics teachers to 3,600 and the need for additional science teachers to 1,800, additional states increasing requirements will increase the number of teachers needed. If all the states implement the increases that have been proposed (our mid-range estimate), the nation will need an additional 7,600 mathematics teachers (rather than 3,600) and an additional 8,300 science teachers (rather than 1,800).

The projected growth in the shortage of mathematics and science teachers implies that school systems may need to use many different approaches to meet their increased need, including recruitment of new teachers, retraining and reassignment of current teachers, and increases in class size. Although most mathematics and science classes would be staffed in some way, it is likely that the process would be a difficult one in many school stystems because of the magnitude of the need for new mathematics and science specialists.

Appendix

High School Mathematics and Science Requirements by State[a], as of January 1984

State	High School Enrollment		Math Requirement Prior to Recent Increases	Recent Math Increases--Actual (A) or Under Study (S)	Science Requirement Prior to Recent Increases	Recent Science Increases--Actual (A) or Under Study (S)
	Total in Grades 9-12	1 High School Cohort[b]				
Alabama	235,000	58,750	1[c]	1 (A)[d]	1[c]	--
Alaska	28,000	7,000	1	--	1	--
Arizona	156,000	39,000	1	1 (S)	1	1 (S)[d]
Arkansas	141,000	35,250	--	--	--	--
California	1,318,000	329,500	local[e]	2 (S)[f]	local	2 (S)[f]
Colorado	181,000	45,250	local	--	local	--
Connecticut	189,000	47,250	local	--	local	--
Delaware	39,000	9,750	1	--	1	--
District of Columbia	31,000	7,750	1	1 (A)	2	--
Florida	477,000	119,250	local	2 (S)[f]	local	--

[a] Includes the District of Columbia.

[b] One-fourth of the enrollment in grades 9 through 12.

[c] Years of mathematics or science currently required (or, as appropriate, required prior to recent increases).

[d] Additional years of mathematics or science.

[e] High school graduation requirements locally determined.

[f] California and Florida currently allow local decisions on graduation requirements but are considering the imposition of state-wide requirements for two years of mathematics (both) and two years of science (California only).

STATE	High School Enrollment		Math Requirement Prior to Recent Increases	Recent Math Increases-- Actual (A) or Under Study (S)	Science Requirement Prior to Recent Increases	Recent Science Increases-- Actual (A) or Under Study (S)
	Total in Grades 9-12	1 High School Cohort				
Georgia	332,000	83,000	1	--	1	--
Hawaii	57,000	14,250	2	--	2	--
Idaho	62,000	15,500	1	1 (A)	2	--
Illinois	676,000	169,000	local	--	local	--
Indiana	361,000	90,250	1	1 (A)	1	1 (A)
Iowa	191,000	47,750	local	--	local	--
Kansas	135,000	33,750	1	--	1	--
Kentucky	211,000	52,750	2	1 (S)	2	--
Louisiana	245,000	61,250	2	1 (A)	2	--
Maine	72,000	18,000	local	--	local	--
Maryland	268,000	67,000	2	--	2	--
Massachusetts	351,000	87,750	local	--	local	--
Michigan	637,000	159,250	local	--	local	--
Minnesota	282,000	70,500	local	--	local	--
Mississippi	156,000	39,000	1	--	1	--
Missouri	294,000	73,500	1	--	1	--
Montana	52,000	13,000	2	--	1	--
Nebraska	97,000	24,250	local	--	local	--
Nevada	50,000	12,500	1	1 (A)	1	--
New Hampshire	59,000	14,750	1	1 (S)	1	1 (S)
New Jersey	440,000	110,000	2	--	1	--
New Mexico	90,000	22,500	2	1 (S)	1	--
New York	1,064,000	266,000	1	--	1	--
North Carolina	354,000	88,500	1	--	2	--
North Dakota	42,000	10,500	1	1 (S)	2	--
Ohio	674,000	168,500	1	1 (A)	1	--

A-2

State	High School Enrollment		Math Requirement Prior to Recent Increases	Recent Math Increases--Actual (A) or Under Study (S)	Science Requirement Prior to Recent Increases	Recent Science Increases--Actual (A) or Under Study (S)
	Total in Grades 9-12	1 High School Cohort				
Oklahoma	185,000	46,250	1	1 (A)	1	1 (A)
Oregon	150,000	37,500	1	--	1	--
Pennsylvania	736,000	184,000	1	--	1	--
Rhode Island	55,000	13,750	1	2 (S)	1	1 (S)
South Carolina	196,000	49,000	2	1 (S)	1	1 (S)
South Dakota	46,000	11,500	1	1 (S)	1	1 (S)
Tennessee	256,000	64,000	1	1 (A)	1	1 (A)
Texas	869,000	217,250	2	1 (A)	2	--
Utah	95,000	23,750	1	--	1	--
Vermont	30,000	7,500	local	--	local	--
Virginia	316,000	79,000	1	1 (S)	1	1 (S)
Washington	250,000	62,500	3	--	2	--
West Virginia	123,000	30,750	1	1 (A)	1	--
Wisconsin[g/]	314,000	78,500	local	--	local	--
Wyoming	29,000	7,250	local	--	local	--

[g/] Since 1980, Wisconsin has had in effect a strong state-wide recommendation for 3 years each of mathematics and science.

Sources: Enrollment data from NCES, 1981b; other data from sources listed for Table 6.

A-3

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